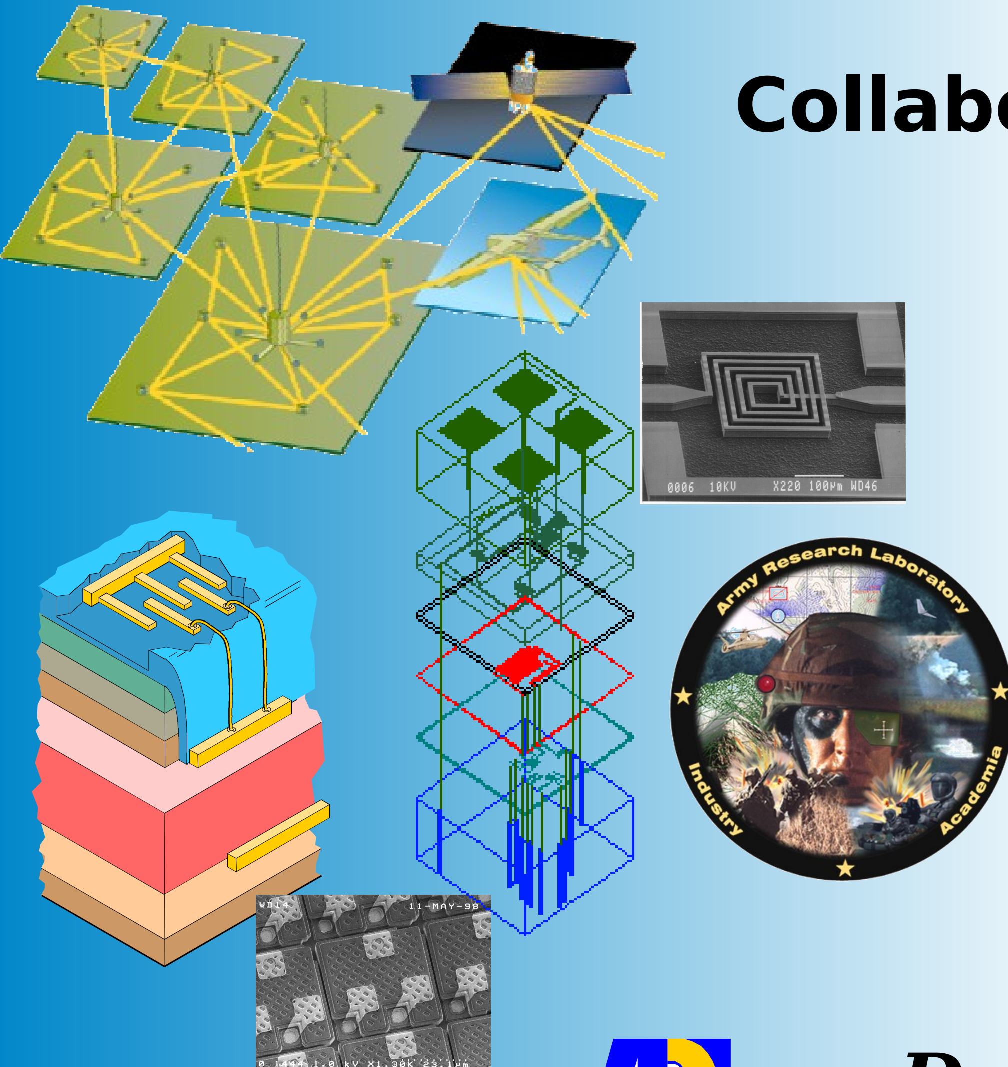


Collaborative Technology Alliance (CTA)

Advanced Sensors

BAE SYSTEMS

Dr. Dan Beekman
ARL Collaborative Alliance Manager

Mr. Steve Scalera
Consortium Manager, BAE Systems, IEWS

Advanced Sensors Collaborative Technology Alliance

Consortium Partners

- BAE Systems
- Northrup Grumman
- DRS Infrared
- Quantum Magnetics
- General Dynamics Robotic Sys Tech
- U. New Mexico
- Clark-Atlanta
- MIT
- U. Maryland
- Georgia Tech
- U. Michigan
- U. Florida
- U. Mississippi

Objectives

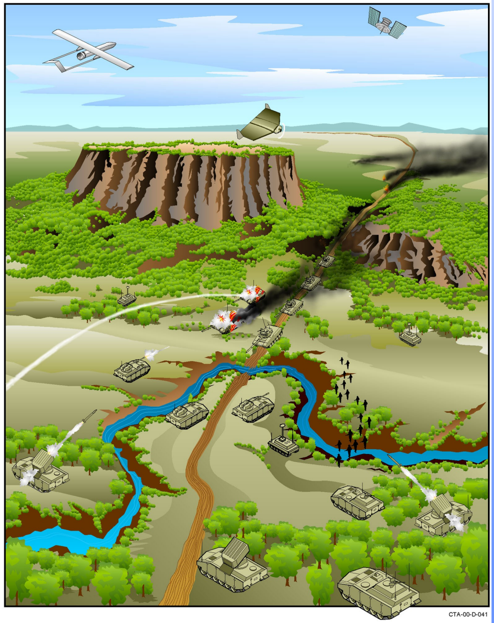
Technologies that increase sensor performance and utility, and techniques to combine many types of data to provide timely and meaningful information to the soldier.

Affordable sensors that provide:

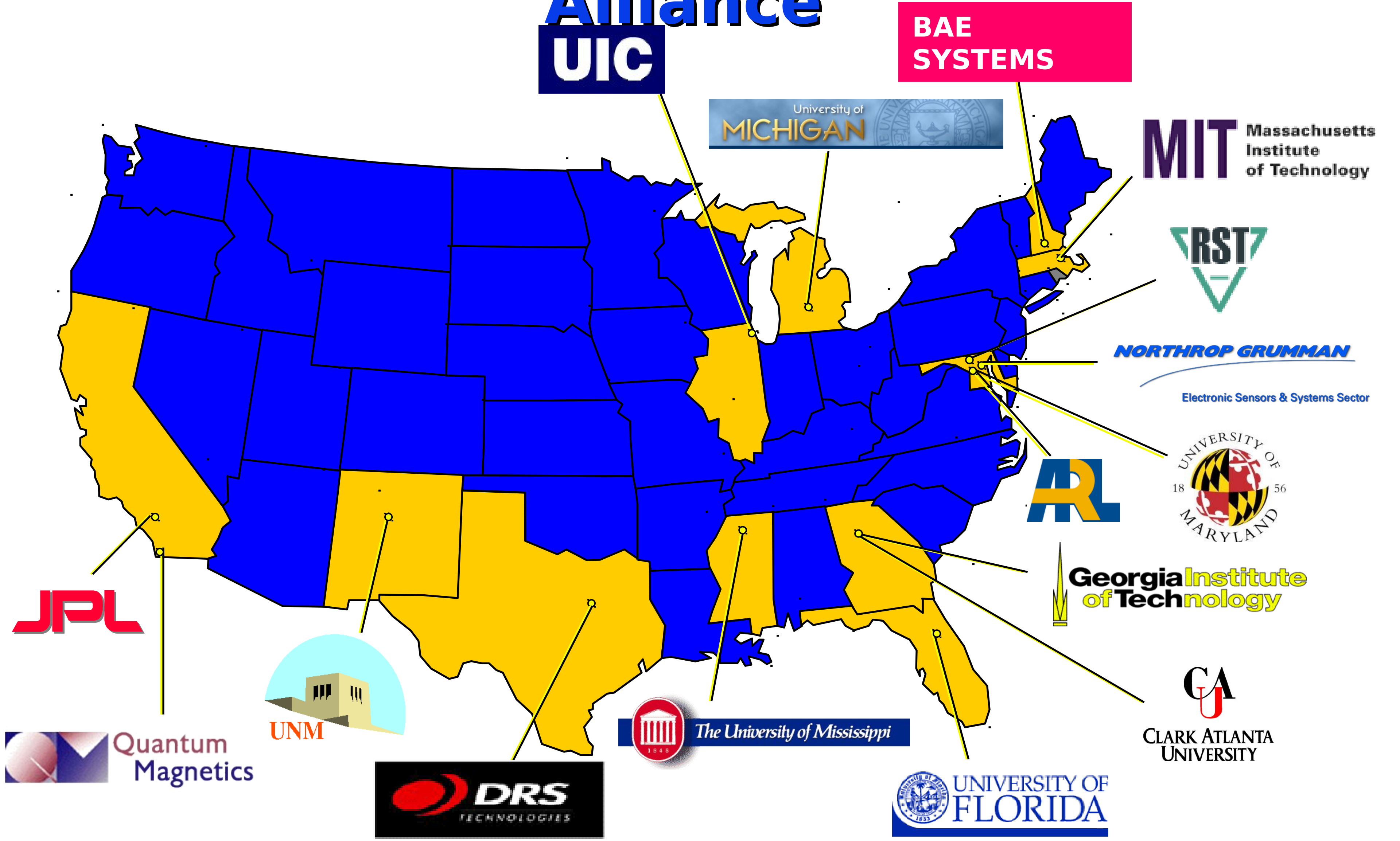
- Continuous situation awareness
- Rapid, precise detection and ID of camouflaged targets
- Environmental sensing for navigation and self-defense

Technical Areas

- Microsensors
- Electro-Optics Smart Sensors
- Advanced RF



Advanced Sensors Collaborative Technology Alliance



Advanced Sensors Collaborative Technology Alliance

ARL CAM: Dr. Dan Beekman
BAE PM: Mr. Steve Scalera

Microsensors

ARL: Nino Srour
BAE Systems: Mark Falco

- Sensors & Sensor Improvements
- Multi-Sensor Fusion Algorithms
- Low-power Signal Processing
- Sensor System Architectures

EO Smart Sensors

ARL: Arnie Goldberg
BAE Systems: Parvez Uppal

- High Operating Temperature FPAs
- Innovative Components for Ladar
- Hyperspectral Imaging Components
- ATR and Image Fusion

Advanced RF Concepts

ARL: Ed Viveiros
BAE Systems: Norm Byer

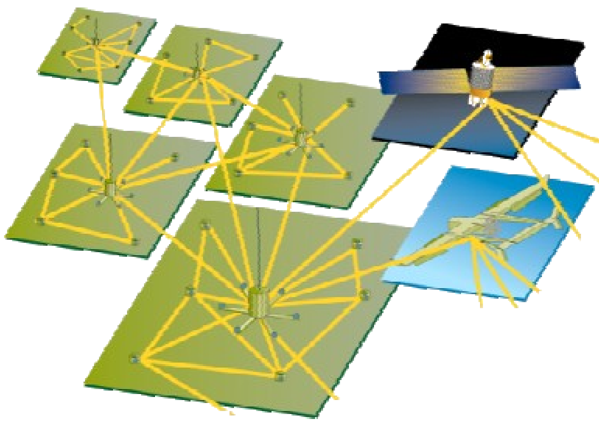
- Systems Study
- Electronically-Scanned Antennas
- Receivers and Waveform Generators
- Devices and Materials

Advanced Sensors Technical Area 1: Microsensors

Objective: **Provide enabling technologies for networked sensors capable of autonomous detection, ID, and tracking of multiple targets while minimizing cost, power, and communications bandwidth.**

Challenges:

- Decreasing sensor cost while maintaining performance
- Very low power signal processing for long operating lifetime
- Reduced communications bandwidth
- Fusing of multiple and diverse sensor data
- Automated sensor deployment
- Autonomous network configuration & management

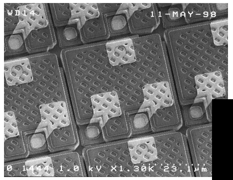


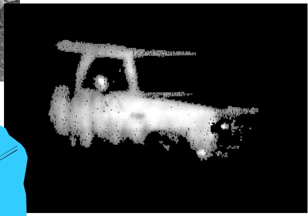
Research Tasks:

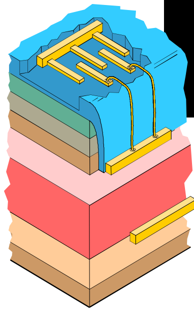
- Sensors & Sensor Improvement
- Multi-Sensor Fusion Algorithms
- Low Power Signal
- Active Wind Noise Cancellation
- Self-calibrating sensors
- Self-organizing sensor networks

Advanced Sensors Technical Area 2: Electro-Optic Smart Sensors

Objective: **Provide enabling technologies for a high-performance multifunction imaging sensor capable of improved target detection and ID for obscured, camouflaged, and low-observable targets.**







Challenges:

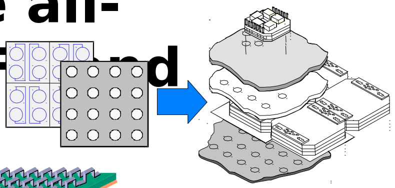
- **Higher operating temperature infrared FPAs**
- **FM/cw ladar at eyesafe wavelengths**
- **Integrated passive infrared and active ladar detectors on a single focal plane array**
- **Acousto-optic hyperspectral imaging at infrared wavelengths**

Research Tasks:

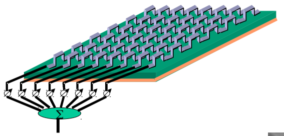
- **Improved HgCdTe and III-V MBE material for infrared detectors**
- **InAs/(GaIn)Sb materials and structures for eyesafe ladar sources & detectors**
- **Crystal growth of high efficiency infrared acousto-optic materials**
- **Algorithms for ATR, signal processing, and image fusion**

Advanced Sensors Technical Area 3: Advanced RF Concepts

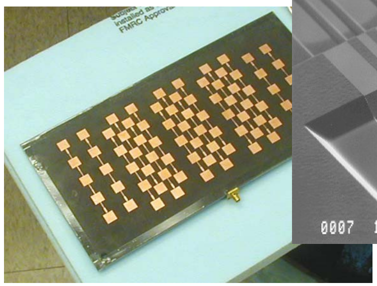
Objective: **Provide enabling subsystem, component and systems studies for low cost multifunction Ka-band RF systems that provide FCS with longer range all-weather operation for radar, communication, IFF and EW/SIGINT functions.**

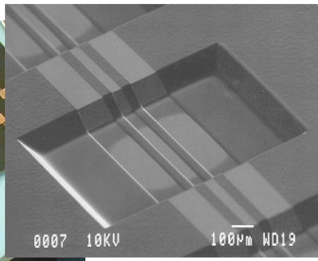


Challenges:



- **Affordable Electronically Scanned Antennas (ESAs)**
- **Reliable low-cost hermetic packaging for reliable MEMS devices**
- **Efficient, high dynamic range power devices for transmit/receive modules**
- **Integration of diverse semiconductor materials**





Research Tasks:

- **Low-cost lightweight VITL ESA**
- **MEMS K_a-band phase control module**
- **Multifunction RF waveforms**
- **MMW propagation in foliage**
- **MHEMT modeling**
- **InP HBT technology**
- **Heterogeneous integration of waveform generator**
- **MMW bistatic scattering phenomenology**
- **MMW GaN materials development**
- **AlGaN HEMT MMW research**
- **MEMS TTD elements & device reliability**

FY01 ASCTA Tasks: EO Smart Sensors

Topic #	*Research Topic*	*Principal Investigator*
EO-01-01	Component Development for Active/Passive Imagers	Parvez Uppal (BAE SYSTEMS), John Little (ARL), Barry Stann (ARL)
EO-01-02	InAs/(GaIn)Sb superlattice-photodetectors for the MWIR and LWIR	Parvez Uppal (BAE SYSTEMS), Richard Tober (ARL)
EO-01-03	Materials Development for HgCdTe Higher Operating Temperature (HOT) Detectors	S. Sivananthan (University of Illinois at Chicago)
EO-01-04	Fabrication of Large Format Higher Operating Temperature (HOT) HgCdTe Detector Arrays	Hung-Dah Shih (DRS Infrared Technologies)
EO-01-05	Novel Approaches to Extending the Operating Wavelength of LADAR Sources	Luke Lester, Kevin Malloy. Julian Cheng and Marek Osinski (UNM)
EO-01-06	Materials development for staggered lineup detectors	Kevin Malloy, Sanjay Krishna, Ralph Dawson (UNM)
EO-01-07	2-5 ? m Mid-Infrared laser Development	Kamjou Mansour (JPL)
EO-01-08	MTI Functionality for Dual Color IR Sequences	Qinfen Zheng (University of Maryland)
EO-01-09	Advanced Target Recognition using Sensor Fusion Algorithms	Bruce Shachter (Northrop Grumman)
EO-01-10	Critical Component Development for Multi-Spectral Imaging	N.B. Singh (Northrop Grumman)

FY02 ASCTA Tasks: EO Smart Sensors

Topic #	*Research Topic*	*Principal Investigator*
EO-02-01	Component Development for Active/Passive Imagers	Parvez Uppal (BAE SYSTEMS), John Little (ARL), Barry Stann (ARL)
EO-02-02a	InAs/(GaIn)Sb superlattice-photodetectors for the MWIR and LWIR	Parvez Uppal (BAE SYSTEMS), Richard Tober (ARL)
EO-02-02b	Materials development for staggered lineup detectors InAs/(GaIn)Sb superlattice-photodetectors for the MWIR and LWIR	Kevin Malloy, Sanjay Krishna, Ralph Dawson (UNM)
EO-02-03	Materials Development for HgCdTe Higher Operating Temperature (HOT) Detectors	S. Sivananthan (University of Illinois at Chicago)
EO-02-04	Fabrication of Large Format Higher Operating Temperature (HOT) HgCdTe Detector Arrays	Hung-Dah Shih (DRS Infrared Technologies)
EO-02-05	Novel Approaches to Extending the Operating Wavelength of LADAR Sources	Luke Lester, Kevin Malloy. Julian Cheng and Marek Osinski (UNM)
EO-02-06	2-5 ? m Mid-Infrared laser Development	Kamjou Mansour (JPL)
EO-02-07	MTI Functionality for Dual Color IR Sequences	Qinfen Zheng (University of Maryland)
EO-02-08	Advanced Target Recognition using Sensor Fusion Algorithms	Bruce Shachter (Northrop Grumman)
EO-02-09	Critical Component Development for Multi-Spectral Imaging	N.B. Singh (Northrop Grumman)
EO-02-10	VCSELs for Data Links	Julian Cheng (UNM) Marek Osinski (UNM), and Kevin Malloy (UNM)
EO-02-11	Cryogenic VCSELs For Optical Read- Out Focal Plane Arrays (FPA)	Aris Christou (UMD)
EO-02-12	Multi-Diciplinary Clean Room Protocol Study & Evaluation	Kamal Sarabundi (University of Michigan)

Accomplishments: EO Smart Sensors

•**Component Development for Passive/Active Imagers.** The development of large format InGaAs/InAlAs/InP arrays has moved forward with the resolution of issues involving dry etching, device isolation etching , and RIE equipment. Hybridization is in progress.

•**Materials Development for InAs/(Ga,In)Sb Superlattice Photodetectors.**. Dry and wet etching techniques for GaInSb/InAs were developed and 8 x 8 arrays have been fabricated.

•**Materials Development for HgCdTe HOT Detectors.** University of Illinois has completed a study on As-doped samples to determine the influence of annealing conditions on transport properties. Research on the ex-situ gold doping of HgCdTe was started at DRS

•**MTI Functionality for Dual Color IR Sequences**. University of Maryland has received sample dual color IR images collected over 72 hours at 1 hour internal from ARL and have begun signature analysis on the data. Further analysis and ATR algorithm development will be performed in the next reporting quarter.

FY01 ASCTA Tasks: RF Concepts

Topic #	*Research Topic*	*Principal Investigator*
RF-01-01	Low Cost, Lightweight VITL ESA	John Apostolos (BAE Systems)
RF-01-02	Integrated Phase Control Module for Ka-Band ESA	Norm Powell (Northrop Grumman)
RF-01-03	Heterogeneous Integration of Receiver and Digital Waveform Generator Circuits	Dr. John Przbysz (Northrup Grumman)
RF-01-04	Multifunction Radar Waveform Design	Jim Kurtz (University of Florida)
RF-01-05	MEMS Devices	Gabriel Rebeiz (UMich)
RF-01-06	MEMS Device Reliability and Packaging	Linda Katehi (UMich)
RF-01-07	Novel Electronic Beam-Scanning Antennas	Kamal Sarabandi (UMich)
RF-01-08	MMW Wave Propagation in Foliage	Kamal Sarabandi (Univ Michigan)
RF-01-09	MMW Bistatic Scattering Phenomenology	Fawwaz T. Ulaby (UMich)

NORTHROP GRUMMAN
Electronic Sensors & Systems Sector

University of MICHIGAN

UNIVERSITY OF FLORIDA

BAE SYSTEMS

FY02 ASCTA Tasks: RF Concepts

Topic #	*Research Topic*	*Principal Investigator*
RF-02-01	Low Cost, Lightweight VITL ESA	John Apostolos (BAE SYSTEMS)
RF-02-02	Integrated Phase Control Module for Ka-Band ESA	Norm Powell (Northrop Grumman)
RF-02-03	Heterogeneous Integration of Digital Waveform Generator Circuits	Dr. John Przbysz (Northrop Grumman)
RF-02-04	Multifunction Radar Waveform Design	Jim Kurtz (University of Florida)
RF-02-05	MEMS TTD Elements and Associated Packaging	Gabriel Rebeiz (UMich)
RF-02-06	MEMS Device Reliability and Packaging	Linda Katehi (UMich)
RF-02-08	MMW Wave Propagation in Foliage	Kamal Sarabandi (University of Michigan)
RF-02-09	MMW Bistatic Scattering Phenomenology	Fawwaz T. Ulaby (UMich)
RF-02-10	MMW GaN Material/Device Development	Ken Chu (BAE SYSTEMS)
RF-02-11	Electrical / Physical Modeling of MHEMT Power Devices	Fawwaz Ulaby (University of Michigan) and Doug Dugas(BAE SYSTEMS)
RF-02-12	InP-Based HBT Technology with On-Wafer Cooling	Saeed Mohammadi (University of Michigan)
RF-02-13	AlGaN HEMT Research for Millimeter Wave Applications	Fawwaz Ulaby (University of Michigan); Lester Eastman (Cornell University)

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Accomplishments: RF Concepts

- **VITL ESA**. An unfolded line was investigated as a steering approach and found to superior to the folded meanderline approach. In tests at 400 MHz the unfolded line exhibited lower loss, better control of delay, and easier manufacture. Varactor diodes have been selected for a 6 GHz, 4 element test system that will be fabricated in the next quarter.

- **InP**. Identified the low-temperature InP to Si bonding technology suitable for cooled InP technology. Identified an all passive Si-based micro-cooling technology suitable for cooled InP technology

- **Bistatic Radar**. Demonstrated experimentally the potential application of the bistatic radar to the detection of rocket-shaped objects positioned slightly above ground.

- **Multifunction RF Waveforms.** Polyphase pulse compression coding, Costas FM, and complementary phase coding - have been selected as multifunction RF candidate waveforms. Computer simulation and analysis has begun on the candidate waveforms, and a set of performance metrics is being generated for comparison purposes.

- **MEMS.** The University of Michigan has developed the technology for low-temperature series switches using parylene, a polymer material. Northrop Grumman also has begun on a new base material, liquid crystal polymer (LCT which promises lower production costs. LCT has excellent RF properties (low loss and dielectric constant), is impermeable to mois ases and liquids, and is readily available

FY01 ASCTA Tasks: Microsensors

Topic #	Research Topic	Principal Investigator
MS-01-01	Non-Linear Spatial Processing and Signal Estimation Algorithms	M. Falco(BAE)
MS-01-02a	Data Collection	S. Blatt (BAE SYSTEMS)
MS-01-02b	Microsensors Data Collection and Data Fusion	Bruce Schachter (Northrop Grumman)
MS-01-03	Multimodal Sensor Fusion	Dr. Paul Neiswander (Northrop Grumman)
MS-01-04	Sensor Management Metrics for Optimization of Unattended Ground Sensor Networks	Dr. Lance Kaplan (CAU)
MS-01-05	Precision Emplacement of Unattended Ground Sensors	Mr. Kevin Bonner (GDRS)
MS-01-06	Sensor Network Performance Evaluation	Loren Clare, Jay Gao (JPL)
MS-01-07	Investigation of Wind Noise Mechanisms and Reduction	Richard Raspet, Henry E. Bass (University of Mississippi)
MS-01-08	Detection Using Acoustic/Imaging Microsensors and Low Power Computing	R. Chellappa, S. Bhattacharya, K.J.R. Liu, S. Shamma (University of Maryland)
MS-01-09	Adaptive Spatial Processing for Random Thinned Arrays	J. H. McClellan (Georgia Tech)
MS-01-10	Magnetic Sensors for Detection of Military Targets	Yacine Dalichaouch (Quantum Magnetics)
MS-01-11	Design an RF Microsensor	Jim Kurtz, (University of Florida)

FY02 ASCTA Tasks: Microsensors

Topic #	*Research Topic*	*Principal Investigator*
MS-02-01	Non-Linear Spatial Processing and Signal Estimation Algorithms	M. Falco(BAE)
MS-02-02	Microsensors Data Collection and Data Fusion	Bruce Schachter (Northrop Grumman)
MS-02-03	Multimodal Sensor Fusion	Dr. Paul Neiswander (Northrop Grumman)
MS-02-04	Sensor Management Metrics for Optimization of Unattended Ground Sensor Networks	Dr. Lance Kaplan (CAU)
MS-02-05	Precision Emplacement of Unattended Ground Sensors	Mr. Kevin Bonner (GDRS)
MS-02-06	Sensor Network Performance Evaluation	Loren Clare, Jay Gao (JPL)
MS-02-07	Investigation of Wind Noise Mechanisms and Reduction	Richard Raspet, Henry E. Bass (University of Mississippi)
MS-02-07a	Investigation of Wind Noise Mechanisms and Reduction (supplement)	Richard Raspet, Henry E. Bass (University of Mississippi)
MS-02-08	Detection Using Acoustic/Imaging Microsensors and Low Power Computing	R. Chellappa, S. Bhattacharya, K.J.R. Liu, S. Shamma (University of Maryland)
MS-02-09	Adaptive Spatial Processing for Random Thinned Arrays	J. H. McClellan (Georgia Tech)
MS-02-10	Magnetic Sensors for Detection of Military Targets	Yacine Dalichaouch (Quantum Magnetics)
MS-02-11	Design an RF Microsensor	Jim Kurtz (University of Florida)
MS-02-12	Low Power Distributed Signal Processing for Microsensors	Anatha Chandrakasan (MIT)
MS-02-13	Self Calibration	Randy Moses (The Ohio State University)
MS-02-14	Field Experiments	Steve Blatt (BAE SYSTEMS)
MS-02-15	Detection and Tracking of Humans/Vehicles using Distributed Imagers	Rama Chellappa and Qinfen Zheng (University of Maryland)
MS-02-16	Data Fusion for Unattended Ground Sensor Networks	Dr. Lance Kaplan (CAU)

Accomplishments: Microsensors

•**Random Thinned Array Processing.** Performance analysis of various subspace beamformers in the presence of sensor position errors was completed. Three types of RTA beamforming have been compared: conventional, deconvolution and minimax. Recent results on the comparison of conventional and deconvolutional beamforming for two-dimensional planar arrays were presented at Asilomar in November 2001

•**RF Microsensor Design.** Improvements have been made to UWB pulsers and sampling detectors. A breadboard UWB transmitter/receiver system has been constructed and tested. Microwave RF tripwire sensors now being built by the Army will also be tested, modified and used on CTA measurement programs**.**

•**Acoustic and Image Microsensor Fusion.** A novel algorithm for detecting and tracking independently moving objects from a video using the MCMC approach was completed. This approach can handle non-Gaussian, non-linear tracking problems in a unified framework and can be used for fusing inertial information, identity, color and shape of the object being tracked. The fusion algorithm uses the inertial sensor information prior to the MCMC algorithm for tracking and structure estimation. Results show that significantly fewer samples are required in the MCMC algorithm when inertial information is used.

•**Distributed Micro Sensor Localization Processing.** Developed techniques t[o] prune the search for an optimal subset ... an UGS network ... he ... ary ... nod

Other Accomplishments

- **Papers:** 5
- **Task Orders:** 4
  - Long-baseline Gradiometer Investigation (Quantum Magnetics)
  - Modular Acoustics & Imaging Sensor (BAE SYSTEMS)
  - Field Programmable Gate Array Signal Processor (Pyramid Technology)
  - Millimeter-Wave MHEMT MMIC Development (BAE SYSTEMS)
  - First Annual Collaborative Technology Alliance (CTA) Conference 2002/2003 CTA Symposium (TMC Design Corp)
- **Workshops:** 4
  - Microsensors (2)
  - RF Concepts (2)

Other Accomplishments, con't

- **Clark Atlanta University**
  - Developed techniques to prune the search for an optimal subset of sensors from an UGS network for target localization when using the stationary localization method.

- **University of New Mexico**
  - Optimized the growth conditions of the InAs/GaInSb strain layer superlattices and provided material to BAE SYSTEMS for device fabrication.
  - Obtained room temperature lasing for optically pumped 2.8-micron lasers.
  - Material optimization for new material GaInAsN for Long Wavelength (>1.3 micron)VCSELs.

- **Staff Rotations:**
  - 4 current (Jesse Pollock, Parvez Uppal, Mark Falco and Su How Lim)
  - 2 in process